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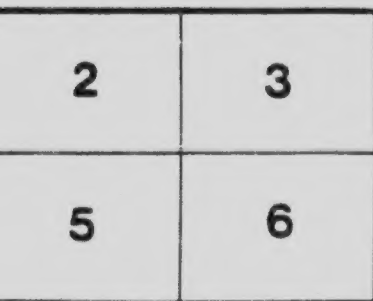
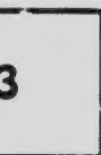
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55

1906

Azimuth Tables

By

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Astronomical Officer, Observatory, Toronto



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AZIMUTH TABLES.

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The following tables have been calculated to enable Surveyors to ascertain the true astronomical meridian. A watch regulated to sidereal time is supposed to be used.

The error of the watch is ascertained by observing the transit of a star across the meridian. A star of the first magnitude is visible with the ordinary telescope of a surveyor's transit theodolite a little after sunrise or before sunset. The observation is a matter of two or three minutes; it may be taken while the work of the survey is going on and without interfering with it.

When the Surveyor is at leisure in camp, he may select a few first magnitude stars passing the meridian at suitable hours and calculate their altitudes. The meridian altitude is the sum of the colatitude (90° - latitude) and of the declination of the star, if north; it is the difference of these quantities when the declination is south. The latitude of the centre of the township will do for any observation within the township.

When the Surveyor has his instrument set up for running the lines of the survey, he may, a little before the time of transit of one of the stars, direct the telescope on the meridian and adjust it to the altitude of the star; looking through the telescope he will soon see the star coming and crossing the vertical thread. The time shown by the watch at that moment should be the right ascension of the star (sidereal time); the difference, if any, is the error of the watch. There is a difference of a few seconds in the time ascertained at various points of a township, but it may be neglected for azimuth observations on Polaris. It must be remembered that the sidereal time obtained at an observation is only accurate in the longitude of place of observation, but, as mentioned above, the time obtained in the limits of a township is close enough.

In case the direction of the meridian is not known, proceed as follows:

By means of the compass, set the instrument approximately to read 360° when the telescope is directed to astronomical north, and clamp the lower plate. With the approximate sidereal time take from Table I the azimuth of Polaris and its altitude. The altitude

is obtained by adding to the latitude the "distance above the pole," or subtracting the "distance below the pole." Set the telescope to the azimuth and altitude thus found and clamp the plates. With the slow motion screw of the lower plate (not the vernier plate) turn the instrument to the right and the left until the star appears, and bisect it with the vertical thread. Now move the vernier of the horizontal circle to read 360°, and observe the TIME star as previously explained. With a time star not too far from the zenith the watch correction thus ascertained is sufficiently accurate for the determination of the meridian by Polaris observations.

An azimuth observation on Polaris may be made as follows:

The instrument being in the position which places the vertical circle to the observer's right hand when looking through the telescope it is directed to the reference object or picket and the verniers then to the POLE STAR, noting the time of pointing on the and then reading the verniers. Reversing the instrument by revolving the telescope and turning the upper plate 180° (not the lower) in azimuth, so that the vertical circle is now to the left of the observer, the telescope is directed to the POLE STAR, the time of pointing again taken and the verniers read. Then a reading on the reference object or picket taken.

For this observation as well as for all star observations the instrument must be carefully levelled.

The time by the watch is, in the explanations which follow, assumed to be corrected for the error of the watch, if any.

The mean of the two sets of readings is taken, and the true azimuth of Polaris is obtained by means of Table I. This table is calculated for a right ascension of 1 h. 30 m. and for a declination of 88° 51'; for other values, it has to be used as follows:

1. For sidereal time argument take the corrected watch time to which has been added the excess of 1 h. 30 m. over the right ascension of Polaris.
2. Interpolate for sidereal time.
3. Interpolate for latitude.
4. Apply the correction from Table II. for declination of Polaris.

In the following examples "H.C.R." is for "Horizontal circle reading," and "R.O." for "reference object." "R.A." and "D."

TABLE

For finding the Pole Star and the Astr

AZIMUTH OF THE PO

Western Elong.	Read down h. m.	Sidereal Time.		AZIMUTH OF THE PO					
				Lat. 43°	44°	45°	46°	47°	48°
ABOVE POLE	1	40	0	42	43	44	44	45	46
	2	0		12.5	12.7	13.0	13.2	13.5	13.8
		20		20.8	21.2	21.6	22.0	22.4	22.8
		40		28.9	29.4	29.9	30.5	31.1	31.7
		0		36.7	37.4	38.1	38.8	39.5	40.3
		20		44.3	45.1	45.9	46.7	47.6	48.6
		40		51.5	52.4	53.3	54.3	55.4	56.5
	4	0		58.3	59.3	1	1.5	2.7	3.9
		20	1	4.6	5.8	6.9	8.2	9.5	10.8
		40		10.5	11.7	12.9	14.3	15.7	17.2
	5	0		15.7	17.0	18.4	19.8	21.3	22.9
		20		20.4	21.8	23.2	24.7	26.3	28.0
		40		24.4	25.8	27.4	29.0	30.8	32.4
	6	0		27.8	29.3	30.9	32.5	34.3	36.1
		20		30.5	32.0	33.6	35.3	37.1	39.0
		40		32.5	34.0	35.7	37.4	39.2	41.2
	7	0		33.8	35.3	37.0	38.8	40.6	42.5
		20	1	34.3	35.9	37.6	39.3	41.2	43.1
		40	1	34.2	35.7	37.4	39.1	41.0	42.9
	8	0		33.3	34.9	36.5	38.2	40.0	41.9
		20		31.7	33.3	34.8	36.5	38.3	40.2
		40		29.5	30.9	32.5	34.1	35.9	37.7
BELOW POLE	9	0		26.5	28.0	29.5	31.0	32.7	34.5
		20		23.0	24.3	25.8	27.3	28.9	30.5
		40		18.8	20.1	21.4	22.9	24.4	26.0
	10	0		14.0	15.2	16.5	17.8	19.2	20.7
		20		8.7	9.8	11.0	12.2	13.5	14.9
		40		2.9	3.9	5.0	6.1	7.3	8.6
	11	0	0	56.6	57.5	58.5	59.5	0.6	1.7
		20		49.9	50.7	51.6	52.5	53.4	54.4
		40		42.9	43.6	44.3	45.1	45.9	46.7
	12	0		35.5	36.1	36.7	37.3	38.0	38.7
		20		27.9	28.3	28.8	29.3	29.8	30.4
		40		20.4	20.4	20.7	21.1	21.5	21.9
	13	0		12.4	12.3	12.5	12.7	12.9	13.2
		20		4.1	4.1	4.2	4.3	4.3	4.4

TABLE
Correction for Declination

Declination of Polaris			Azimuthal	
			20°	40°
88	48	0	0.9	1.4
		10	0.9	1.6
		20	0.8	1.5
		40	0.8	1.2
		50	0.7	1.0
88	49	0	0.7	1.1
		10	0.6	1.0
		20	0.5	0.9
		30	0.5	0.8
		40	0.4	0.8
88	50	0	0.4	0.7
		10	0.3	0.6
		20	0.2	0.4
		30	0.2	0.3
		40	0.1	0.2
88	51	0	0.0	0.0
		0	0.0	0.0

TABLE I.

the Astronomical Meridian.

THE POLE STAR

						%ereal Time.	Distance of the Pole star above or below the pole	
48°	49°	50°	51°	52°	53°	Read up h. m.	ABOVE POLE	BELOW POLE
46	0	47	0	48	0	50	1	20
43.8		44.1		44.4		45.0	1	0
42.8		23.3		23.8		24.3		10
31.7		32.4		33.0		33.6		20
40.3		41.1		42.0		43.9	0	0
48.6		49.6		50.7		51.8		10
56.5		57.6		58.9		60.2		20
3.9	1	5.2	1	6.6	1	8.1	23	0
10.8		12.3		13.8		15.5		10
17.2		18.8		20.4		22.2		20
22.9		24.6		26.4		28.3	22	0
28.6		29.8		31.7		33.7		10
32.4		34.3		36.3		38.4		20
36.1		38.0		40.1		42.3	21	0
39.0		41.0		43.1		45.3		10
41.2		43.2		45.3		47.6		20
42.5		44.6		46.8		49.1	20	0
43.1		45.2		47.3		49.6		10
42.9		45.0		47.1		49.4	1	20
41.9		44.0		46.1		48.4		0
40.2		42.2		44.3		46.5		10
37.7		39.6		41.6		43.8		20
34.5		36.5		38.3		40.3	18	0
30.5		32.2		34.2		36.1		10
26.0		27.6		29.4		31.3		20
20.7		22.3		23.9		25.7	17	0
14.9		16.4		17.9		19.5		10
8.6		9.9		11.3		12.8		20
1.7		2.9		4.1		5.5	16	0
51.4	0	55.4	0	56.5	0	58.9		10
46.7		47.6		48.6		50.6	0	20
38.7		39.4		40.2		41.9	5	0
30.4		31.0		31.6		32.9		10
21.9		22.3		22.7		23.7		20
13.2		13.4		13.7		14.3	14	0
4.1		4.5		4.7		4.8	13	10

TABLE II.

Declination additive to table I.

Azimuthal Angle in Table I

40°	60°	80°	100°	120°
1.4	2.6	3.4	4.3	5.2
1.6	2.5	3.2	4.1	4.9
1.8	2.3	3.0	3.8	4.6
1.9	2.2	2.8	3.6	4.3
2.0	2.0	2.6	3.3	4.0
2.1	1.9	2.5	3.1	3.8
2.2	1.7	2.3	2.9	3.5
2.3	1.6	2.1	2.6	3.2
2.4	1.4	1.9	2.4	2.9
2.5	1.3	1.7	2.1	2.6
2.6	1.2	1.5	1.9	2.3
2.7	1.0	1.3	1.7	2.0
2.8	0.9	1.1	1.4	1.7
2.9	0.7	0.9	1.2	1.4
3.0	0.6	0.8	1.0	1.2
3.1	0.4	0.6	0.7	0.9
3.2	0.3	0.4	0.5	0.6
3.3	0.1	0.2	0.2	0.3
3.4	0.0	0.0	0.0	0.0

are the "Right ascension and declination" of Polaris taken from the Almanac.

EXAMPLE

DATE.—July 30, 1906..... R.A. 1h. 25m. 19s.

PLACE.—9 miles south of 96 mile post on O.L.S. Dec'l. $88^{\circ} 48' 1''$

Niven's 2nd base line and one mile east on the south boundary of Tp.

R.O.—Back Picket on S. boundary line of Tp. and 21 chs. 22 lks. west of the instrument.

Latitude $49^{\circ} 27' 41''$

Chord Azimuth from N. towards E..... $89^{\circ} 55' 20''$

Half Convergence $0^{\circ} 4' 40''$

The convergence at one mile amounts to $1' 2''$ which in this example has to be subtracted from the supplement of $89^{\circ} 55' 20''$, as the azimuth of the back picket is measured from N. towards W.

Face	H.C.R. on R.O.		H.C.R. on Polaris		Watch Time
Right.....	140	51	231	8	14h. 41m. 10s.
Left.....	140	53	231	12	14 44 50
Mean.....	140	52	231	10	14 42 50
1h. 30m. - R.A.....					+ 4 41
Sidereal time argument.....					14 47 31

Tabular Az. for 14h. 40m. and lat. 49° (Table I)..... $31^{\circ} 0'$ East

Difference for 7m. 31s. + 3.2

Difference for $27' 41''$ in latitude..... + 0.3

Correction for Declination (Table II)..... + 1.3

$0^{\circ} 35.8'$ East

H.C.R. on star..... 231 10.0

True North..... $230^{\circ} 34' 12''$

H.C.R. on R.O..... 140 32 0

$90^{\circ} 2' 12''$ West

Azimuth by account.....	90° 33' 38" We
Correction	1° 20'

This shows that the line was bearing too much to the south. To correct this the instrument may be placed a certain number of inches to the north at right angles to the line. This offset is found by multiplying the distance of the back picket by the tangent of the correction, thus :

Log 792 inches in a chain.....	2.89873 constant
Log. tan. of 1° 26'.....	6.62007
Log. dist. 21 chs. 22 lks.....	1.32675
Log. offset.....	0.8.....5
Offset in inches.....	7.3

For the convenience of Surveyors the R.A. of Polaris will be found in the calendar of the *Canadian Almanac* for 1907 and the declination on page 34.

The mean places of the stars on page 32 will be found sufficient for Azimuth work. The column marked "Right Ascension" will be the sidereal time of the stars on the Meridian.

The following approximate formulæ will be found amply sufficient and simple for finding chord azimuths in township work.

$$\text{Tan. } \frac{1}{2} \text{ chord Az.} = \frac{\sin. (s - \alpha)}{\sin. s}$$

$$\alpha \text{ (in seconds of arc)} = (\text{chord in chains} \times 0.65165)$$

It will never amount to more than a few minutes of arc.

$$s = (\text{colatitude} + \frac{1}{2}\alpha)$$

EXAMPLE

What is the chord azimuth for a chord of 718 chs., this being the length of chord necessary for 9 mile⁺ townships on O.L.S. Niven's 2nd Base line? The northern corners of the townships being in latitude 49° 43' 19". Niven's Base line in latitude 49° 35' 30".

$$\begin{aligned}
 a &= 718 \text{ chs.} \times 0.65165 = 7' 47''.9 \\
 \text{Colatitude} &= 90^\circ - 49^\circ 43' 19'' = 40^\circ 16' 41'' \\
 s &= 40^\circ 16' 41'' + \frac{7' 47''.9}{2} = 40^\circ 20' 35'' \\
 s-a &= 40^\circ 12' 47'' \\
 \text{Log. sin. } (s-a) &= 9.8099851 \\
 \text{Log. sin. } s &= 9.8111477 \\
 &2) 9.9988374 \\
 \text{Log. tan. } \frac{1}{2} \text{ Az.} &= 9.9994187 \\
 \frac{1}{2} \text{ ch. Az.} &= 44^\circ 57' 42'' \\
 &2 \\
 \text{Ch. Az.} &= 89 \quad 55 \quad 24 \text{ from the N.} \\
 &\quad 90 \quad 0 \quad 0 \\
 \frac{1}{2} \text{ Convergence} &= \quad 4.36
 \end{aligned}$$

Similarly the half convergence for townships laid out on the south side of Niven's 2nd Base line is equal to $4' 40''$ and the length of the southern boundaries of the Townships is $721^\circ 91''$ the latitude being $49^\circ 27' 41''$.

